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DAMP MASONRY WALLS ABOVE GRADE[1/]

I. Introduction

II. Causes of dampness

a. Condensation moisture
b. Penetration of rain water
c. Capillary rise of ground moisture

III. Preventative measures

a. Condensation moisture
b. Penetration moisture

1. Ground moisture
2. Water entering through horizontal surfaces
3. Water entering through vertical surfaces

I. Introduction

Many inquiries regarding causes and methods of prevention of dampness on the interior surfaces of exterior walls of brick,

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1/ Methods of waterproofing walls below grade are discussed in the following publications:

Farmers' Bulletin No. 1572, "Making Cellars Dry," obtainable from the Superintendent of Documents, Washington, D. C., for five cents.

"Waterproofing Engineering," by Joseph Ross, John Wiley and Sons, New York, N. Y.

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structural clay tile, concrete block, stone and stucco have been

received by this Bureau. This letter circular has been prepared to give information on the subject more fully than would be feasible by a letter.

Although nearly all building walls are permeable in the sense that they would leak if subjected to water under pressure, most walls of all types give satisfactory service except under very severe conditions. Descriptions and observations of structures where dampness has occurred indicate that faulty design or construction usually is the cause. Apparently the possibility of damp walls is not always considered during construction. The masonry materials sometimes are used as if they were impermeable, whereas many types are readily permeable.

Dampness on the interior surfaces of walls may arise from the following sources: (1) moisture condensed from the air, (2) moisture entering through openings, and (3) moisture permeating through the wall.

II. Causes for Dampness

a. Condensation moisture

Atmospheric moisture condenses on a wall whenever the temperature of the wall surface is less than the dew-point temperature of the adjacent air. The amount of moisture deposited will depend mainly on the temperatures of the wall and air, the relative humidity of the air, and the rate of movement of the air over the wall surface. The dew-point temperature depends chiefly on the temperature and relative humidity of the air. Minimum differences between the temperature of the wall surface and of the adjacent air, for various relative humidities, at which condensation will occur are approximately as follows:

Relative humidity of the air, Per cent	Minimum differences between temperatures of adjacent air and of wall surface for condensation, °F.
30	33
50	20
70	10
90	3

Condensation may take place during cold weather if there is insufficient thermal insulation between the wall surface and its backing because large differences may then exist between the temperature of the masonry surface and of the air in the room. As changes in wall temperatures tend to lag behind changes in air temperatures, a sudden rise in the temperature of air may cause moisture to condense on walls.

Due to the fact that the relative humidity of air in dwellings generally is very low while heating plants are in operation, dampness from condensation during cold weather is not common. However, with air conditioning or when humidifying devices are used, wall insulation usually will be needed if outdoor temperatures are less than 30°F. The thermal insulation provided by furring alone is not an adequate safeguard where temperatures as low as 10°F. are experienced unless the relative humidity is maintained at less than 60 per cent. Estimates of the amount of insulation required can be made readily by engineers if provided with information on the wall construction and on the operation of the air conditioning equipment.

When walls become damp during rainy weather only, sometimes it is not readily apparent whether the source of moisture is

condensation from the air or rain water permeating through the wall. To answer this question a simple test may be made by cementing a thin piece of metal, having a polished surface, or a mirrored glass, onto the face of the wall. If moisture collects on this surface whenever dampness appears on surrounding portions of the wall, it may be concluded that condensation contributes to the dampness.

In interpreting the results of such tests, it should be borne in mind that moisture may condense on a wall surface without causing noticeable dampness on the interior if the wall absorbs the moisture as rapidly as it is deposited. Although the wall surface does not appear to be damp, the condensation of moisture may have a deleterious effect on the plaster or decorations.

b. <u>Penetration of rain water</u>

Dampness on interior surfaces of walls may be caused by rain water blown against the walls or by water collected on roofs or other horizontal surfaces entering the masonry and reaching the interior, sometimes at a considerable distance below the place of entry.

Structural defects which permit the drainage water to flow onto or into the masonry are believed to be the most common causes of dampness in masonry walls. The nature of the defects is well known, but in order to avoid them it is necessary for the designer to make plans for conveying rain water away from the masonry and for the builder to carry out the details with care.

The likelihood of rain entering through exposed vertical faces of walls in sufficient amounts to cause dampness on interior surfaces is largely dependent upon wind velocity, intensity and duration of rainfall, and the location of objects tending to shield the wall. Without wind no rain would strike the vertical surfaces; a horizontal wind of 10 miles per hour would cause roughly two-thirds as much rain to strike an unprotected vertical surface as would fall on equal horizontal surfaces; a velocity of 30 miles per hour would increase the amount to twice as much as would fall on equal horizontal surfaces. Surrounding objects such as buildings and trees may reduce considerably the amount of rain which strikes vertical surfaces.

In many localities a rainfall totalling two to three inches in from one to three days and accompanied by winds having a velocity of 15 to 30 miles per hour may be expected many times during the life of a building. During such rains the amount of water which strikes unprotected vertical surfaces may total from 2 to 6 cubic inches per square inch of wall. The water capacity of bricks in a brick masonry wall 8 inches thick ranges, for different products, from less than 1 to about 4 cubic inches per square inch of exposed brick area; for most bricks this value lies between 1 and 3 cubic inches per square inch. It is apparent, therefore, that the amount of water which may strike a wall during such a storm may be more than sufficient to saturate a brick masonry wall 8 inches thick. The water capacity of other kinds of masonry does not exceed that of the most absorptive brickwork.

The rate at which initially dry bricks absorb water through

one face which is in contact with water varies from 0.1 to more than 5 cubic inches per hour per square inch of exposed surface. However, the rate for most common bricks and for most masonry of other units lies between 0.2 and 2 cubic inches per hour per square inch. As the effect of wind pressure on the rate of absorption ordinarily is small in comparison with the effect of capillary forces, the chief influence of wind on the moisture gain of a wall without cracks or other openings is in its effect on the quantity of water which strikes the vertical face. The foregoing values on rates of absorption indicate that walls composed of rapidly absorbing bricks are capable of absorbing water as rapidly as moisture is supplied by rain except during unusually heavy downpours accompanied by strong wind; whereas with bricks which absorb slowly, rains of ordinary intensity with moderate winds may supply water more rapidly than it can be absorbed.

The time required for moisture to penetrate a wall probably is not affected significantly by the presence of capillary cracks if the masonry is capable of absorbing relatively large volumes of water with extreme rapidity. However, with most masonry and stucco, especially that which absorbs moisture slowly, wind-blown rain will be driven easily through cracks, because storms of only ordinary intensity may supply water at a rate exceeding that at which water will be absorbed by the material.

The results of tests show that moisture penetrates more rapidly through either bricks or mortar than through solid brickwork composed of both materials, the movement of the water

apparently being retarded as it passes from one material to the other. It seems, therefore, that masonry having all spaces between the units filled solidly with mortar would be preferable to that with joints only partially filled because (1) it has a greater capacity for holding moisture and (2) there is a lesser likelihood of water being concentrated at the header bricks or other bonding units in the spaces between wythes.

c. Capillary rise of ground moisture

Capillary moisture from the ground is not a frequent cause of dampness in walls above grade. But the dampproofing necessary to avoid trouble from this source is so simple and inexpensive that it should not be omitted.

III. Preventative Measures

a. Condensation moisture

Thermal insulation should be provided between the interior surface and the masonry wall. The amount of added insulation need not be large for ordinary dwellings where there is little or no artificial humidifying of the air. It may be simply an air space or sheets of insulating material such as corkboard, rock cork or a fibrous or mineral insulation board 1/2 inch or more in thickness. If the insulation is provided by furring the width of the air space should be approximately 3/4 inch, because for narrower spaces the insulating value is low and for wider spaces it is not increased appreciably. Methods of applying insulation materials are described in specifications prepared by manufacturers of these materials.

If the humidity of the air in the buildings is unusually

high (as is likely in laundries, for example) ventilation will be an aid in preventing dampness from condensation. However, in new structures or in remodeling old ones for uses that may increase the humidity of the air, the amount of insulation required to prevent condensation should be ascertained.

b. Penetration moisture

1. Ground moisture.--To overcome dampness from capillary moisture from the ground, dampproofing courses should be extended entirely through the wall at a height of 5 to 10 inches above the surface of the ground. These courses may consist of layers of impervious materials, such as slate or sheet copper. As an optional method, mortar containing a water repellent may be used for three or more courses of the masonry. Cements in which the water repellent is incorporated are generally available, or the repellent ingredients may be purchased in the form of pastes or powders and incorporated in the mortar. These materials usually consist of salts of fatty acids, such as stearates or oleates of ammonium, sodium, or calcium. The sodium and ammonium salts are found on the market in the form of pastes, while the calcium type may be obtained as a dry powder, usually consisting of hydrated lime and calcium stearate. The amount of such admixture used should provide a fatty acid content equal to from 0.1 to 0.2 per cent of the weight of the cementing materials. The producers' specifications usually give the amounts of their admixtures to use, which is ordinarily about 2 per cent of the weight of the cementing materials. The pastes are added to the mixing water, but the dry powders are mixed with the sand and cement before water is added.

For stone masonry, especially of limestone and sandstone, it is considered good practice to use a granite base or at least one course of granite extending through the wall and slightly above the ground line. Such grade courses should be bedded and jointed in a dampproofed mortar as described above.

2. <u>Water entering through horizontal surfaces</u>.--All horizontal or sloping surfaces, unless continuous and nearly impervious, should be either waterproofed or separated from the masonry below by flashing of durable materials. For example, copper flashing may be provided under copings, cornices, caps on chimneys, pervious or jointed sills, and projecting courses of masonry. In furred wall construction flashing should be installed at the tops of window frames and wherever members join the plaster with the masonry, in order to divert water from the inner face of the masonry to the outside. At junctions between parapet walls and roofs, the flashing which is built into the roof surfacing should be extended upward high enough to prevent overtopping by roof water and then through the wall to within one inch of the outer surface. Construction which projects beyond the exposed vertical faces of walls should be provided with undercut drips, in order to shed the water away from the walls.

Openings and defective joints should be filled with mortar or with a plastic caulking compound (sometimes called elastic pointing material), after which two or more coats of a colorless liquid waterproofing should be applied to the entire surface.

3. <u>Water entering through vertical surfaces</u>.--The possibility of dampness penetrating through vertical walls should be

taken into consideration in the original plans and specifications. In order to obtain well filled joints and a complete contact of mortar with the masonry units, it is essential that the mason use a mortar of good working properties. With units which absorb water slowly mortars of stiffer consistency should be used than with those which absorb water rapidly. For the latter, it is preferable to use mortars which offer a considerable resistance to loss of moisture when in contact with absorbent units. Masonry units which absorb water slowly should be dry when laid and those absorbing water rapidly should be damp but not wet enough to cause them to slide on the mortar bed. The amount of water in the unit preferably should be such that, when one face is in contact with water, the absorption during the first minute will be between 0.1 and 0.6 lb. per sq. ft. of contact area (approximately 0.05 to 0.3 g per sq. cm.).

The data given in the preceding paragraphs on the amount of rain water which may strike vertical surfaces and on the water capacity of masonry walls indicate that the most effective method for repairing walls depends on the absorptive properties of the masonry. Walls of materials which absorb water slowly or in relatively small amounts are more apt to transmit moisture through cracks or other openings than through the solid masonry. Sealing of these openings, therefore, would be the most effective means of stopping leaks. The application of waterproofing to the surface of masonry which transmits moisture slowly probably would be of no benefit. The sealing of openings would tend to reduce leakage through walls of any of the materials in common use, though the reduction would be less with walls which absorb

unusually large amounts of water rapidly. The application of an effective waterproofing compound, after the sealing of openings, also would tend to reduce leakage through masonry of materials which transmit moisture at moderate or rapid rates, and probably would be entirely effective in stopping leaks through walls of large water capacity.

Repairs to flashings and waterproofing of horizontal surfaces should always precede the application of a treatment to vertical surfaces. Openings in joints around window frames or where the masonry joins other materials should be filled, preferably with a plastic caulking compound. As openings large enough to be seen cannot be sealed with a colorless waterproofing, these should be filled and the joints in the masonry should be repointed where there is doubt about their tightness. Vertical joints are often defective and should be repointed. The foregoing repairs may prevent dampness on interiors without the waterproofing of vertical surfaces. Moreover, the partial sealing of vertical surfaces by means of coatings when water may enter behind those surfaces may increase dampness on interiors, accelerate disintegration, and increase efflorescence.

Where it is known that water passes through the masonry units and causes damp interiors, one may resort to a colorless liquid waterproofing treatment. There are several types of such waterproofings on the market, the majority of which fall under the following classification: (1) metallic salts of fatty acids (aluminum stearates and oleates) dissolved in mineral spirits or other suitable solvent, (2) waxes dissolved in mineral spirits, (3) waxes applied in a molten state, (4) thinned

oils alone or with waxes in solution, and (5) thinned varnishes.

A study of such waterproofings by means of exposure tests[2]

2/ Exposure tests on colorless waterproofing materials, Bur. of Standards, Tech. Paper No. 248.

has indicated that materials under the first classification are effective in waterproofing most types of masonry, but when exposed to the weather they deteriorate within two or three years. When properly applied, this type has the advantage of being free of discoloration effects on all types of masonry. Materials under the second classification usually discolor masonry more or less, but they are superior in durability. When the wax used is a good grade of high melting point paraffin, the treatment should be effective for 10 years or longer. The molten wax type usually consists of a high melting point paraffin. With this wax the results are similar to those obtained with paraffin solutions. The treatment is rather expensive as it requires special equipment and skilled workmen for its application. Materials under the fourth classification discolor considerably and are not as durable as the wax treatments. Thinned varnishes discolor considerably most types of masonry and usually leave a film on the surface which is especially noticeable on dense masonry units.

The paraffin solution can be made at small cost by dissolving about 3/4 lb. of paraffin (melting point 135°F. or higher) to the gallon of benzene or gasoline. The solution is easily made when the temperature of the solvent is 70°F. or higher by shaving the wax into the solvent and stirring. It may be made

also by melting the wax and pouring it into the solvent, but care must be taken not to bring either the solvent or the solution near an open flame. This waterproofing may be applied with a brush, but a spray is more satisfactory in most cases. The masonry should be thoroughly dry, and the treatment should not be applied when the wall temperature is below 70°F. Two coats are usually required and the first should be allowed to dry for 24 hours or more before the second is applied. It should be applied copiously, but as soon as the masonry stops absorbing freely the application should be stopped.

Waterproofing (usually bituminous) is sometimes applied to the inner faces of walls. There is some doubt, at least, regarding the value of such waterproofing. Reports of experience indicate that many walls so treated had become damp during heavy rains and with some of these the waterproofing has blistered and become loosened from the masonry. The information available is inadequate to indicate whether or not the waterproofing of interior faces is of benefit, as it is probable that some of the failures reported were due to inferior materials or workmanship.